Air Quality Monitoring:

Lake Wabamun Area

Nov 2004 - Oct 2007 **Final Report**

Overview

Air quality surveys in seven communities around Lake Wabamun were conducted between November 2004 and October 2007. The study was conducted to collect general air quality information. The Mobile Air Monitoring Laboratory (MAML) was used to collect a total of 90 hrs of data.

Concentrations measured did not exceed Alberta's one-hour Ambient Air Quality Objectives. The maximum one-hour average concentrations measured during the study were:

- 84% of the one-hour air quality objective for ozone
- 21% of the one-hour air quality objective for sulphur dioxide
- 13% of the one-hour air quality objective for nitrogen dioxide
- 1% of the one-hour air quality objective for ammonia
- 2% of the one-hour air quality objective for hydrogen sulphide
- 22% of the one-hour air quality objective for carbon monoxide

The current study is a follow up to one conducted in 2000/01. With the exception of larger particles, concentrations measured in 2000/01 were comparable to those observed during the current study. Large particles measured during the 2000/01 study in part were likely due to road and wind blown dust.

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Alberta
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1. Introduction

Alberta Environment conducts unannounced air quality surveys throughout the province as part of its air quality monitoring program. Air quality surveys in several communities around Lake Wabamun were conducted between November 2004 and October 2007. The Mobile Air Monitoring Laboratory (MAML) was used to conduct these surveys. The MAML is equipped to monitor a number of gases, particulate matter and meteorological conditions at the site. The data collected by the MAML provides a "snapshot" of the air quality in time and space.

Air quality data were collected at seven monitoring locations. At most locations, sampling was conducted for a total of 15 hours, for a study total of 90 hours of data. One-hour average concentrations are compared to Alberta Ambient Air Quality Objectives (AAAQO) and concentrations measured at other locations in the province.

The current study is a follow up to one conducted in 2000/01. Studies in the Wabamun area were conducted to collect general air quality information. With the exception of larger particles, ***median one-hour average*** concentrations measured in the 2000/01 were comparable to those observed for the current study. Elevated concentrations of large particles during the 2000/01 study were likely due to road and wind blown dust.

2. Monitoring method and location

The locations of the seven monitoring sites are indicated in Figure 1. All of these sites were also included in the 2000/01 study. The monitoring sites were located at a number of communities around the Wabamun Lake area. The names of the communities where these sites were located are listed in Table 1.

The MAML was used to conduct these surveys. It is equipped to measure ammonia, carbon monoxide, hydrocarbons, oxides of nitrogen, ozone, particulate matter, reduced sulphur compounds, sulphur dioxide, wind speed and direction, relative humidity and temperature, simultaneously. Of particular interest to this study were concentrations of oxides of nitrogen, particulate matter and the sulphur compounds. A description of the MAML and the detection limit of the various instruments onboard are given in Appendix B.

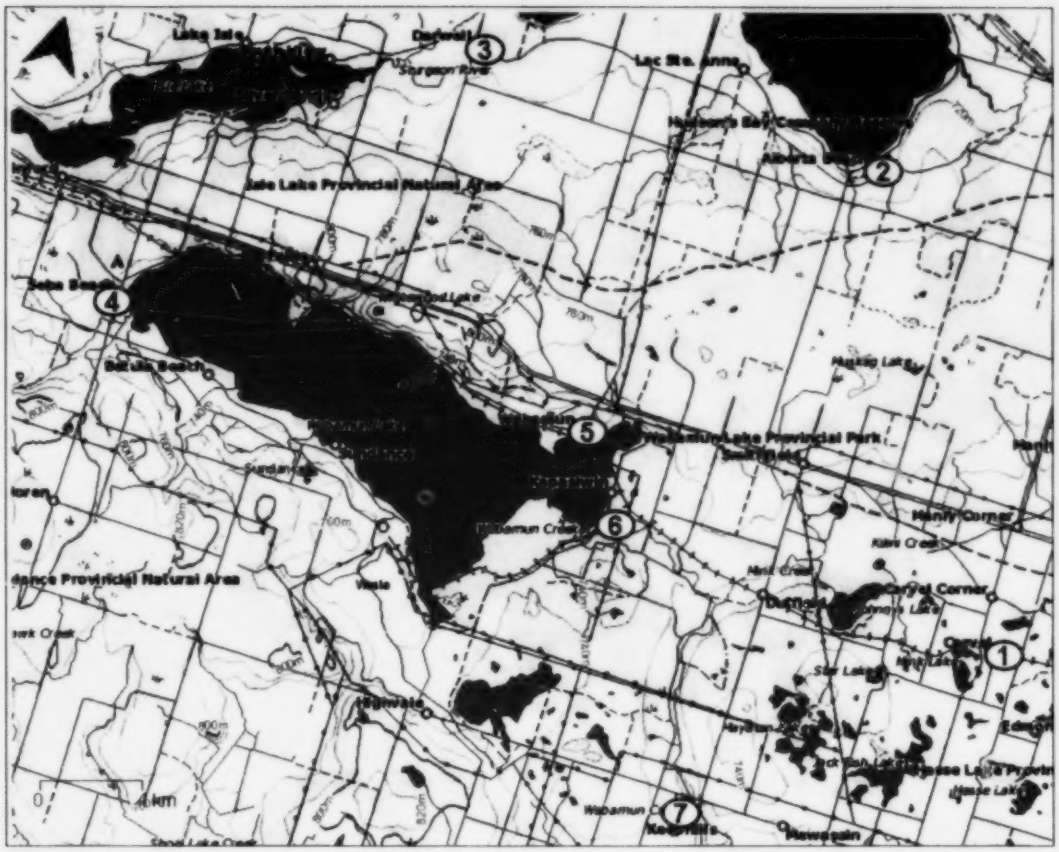
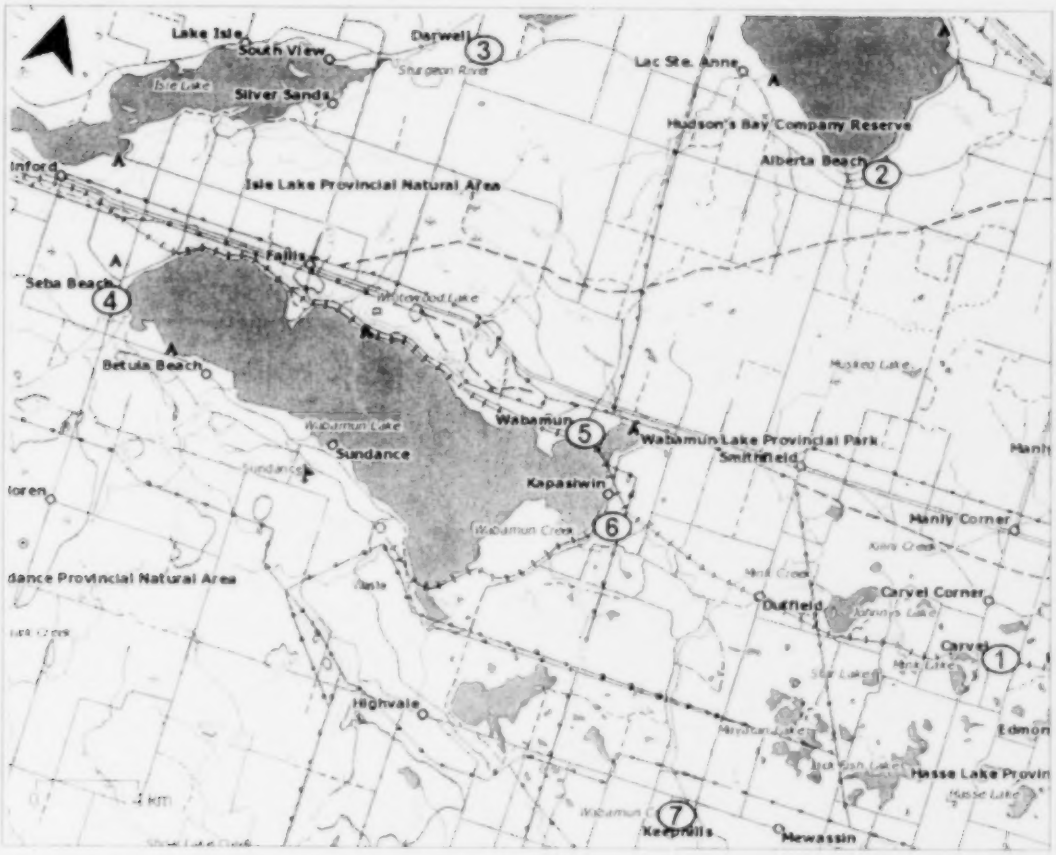


Figure 1: Map of sample sites. The base map for this figure was obtained from *The Atlas of Canada*[1].

Table 1: Monitoring locations

Monitoring site	Location
1	Carvel
2	Alberta Beach
3	Darwell
4	Seba Beach
5	Wabamun marina
6	Ironhead golf course
7	Village of Keephills

[1] http://atlas.nrcan.gc.ca/site/english/maps/topo/map



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3. Results and Discussion

One-hour averages are used to discuss monitoring results at the seven sites. The median one-hour average is used to present the central value for the monitoring period at each of the stations. The median concentration is a common way of representing the central value for environmental data. Further justification for using the median concentration and information on AAAQO are presented in Appendix B. The maximum one-hour averages are compared to AAAQOs.

The median and maximum one-hour averages for all the pollutants measured are presented in Table 2, also in this table are existing AAAQOs. The result section focuses on concentrations for pollutants that are relevant to the area of study. When discussing the results, the median and maximum concentrations are represented graphically. The key in Figure 2 illustrates how to interpret these figures.

The concentration of certain pollutants that Alberta Environment monitors can be below the lower detection limit of the instruments onboard the MAML. A dataset may contain a large number of concentrations below the detection limit and a few concentrations within the operating range of the MAML instruments. In such cases, it is possible to have a median one-hour average concentration that is 'undetectable' or below the lower detection limit (***bd***) while still having a 'detectable' maximum one-hour average concentration.

Table 2: Median and maximum one- hour average concentrations measured during the current study

Site	Location	Number of 1-hr samples	CO PPM	O_3 PPM	THC PPM	CH_4 PPM	RHC PPM	SO_2 PPM	NO PPM	NO_2 PPM	NO_x PPM	NH_3 PPM	TRS PPM	H_2S PPM	TSP* $\mu g/m^3$	PM_{10} $\mu g/m^3$	$PM_{2.5}$ $\mu g/m^3$	PM_{1}* $\mu g/m^3$	PAH ng/m^3
			Median 1-hour average																
1	**Carvel**	9	0.3	0.030	2.0	2.0	bd	0.003	0.004	0.006	0.008	0.001	bd	bd	22	13	5	4	bd
2	Alberta Beach	15	0.2	0.030	2.0	2.0	bd	0.003	0.004	0.004	0.007	0.001	bd	bd	21	13	5	5	bd
3	**Darwell**	6	0.2	0.023	2.1	2.1	bd	0.005	0.006	0.008	0.012	bd	bd	bd	17	11	4	4	bd
4	Seba Beach	15	0.2	0.031	1.9	1.9	bd	0.003	0.003	0.004	0.006	0.001	bd	bd	19	10	2	3	bd
5	**Wabamun**	15	0.2	0.037	1.9	1.9	bd	0.003	0.003	0.004	0.006	0.002	bd	bd	12	7	3	3	bd
6	Ironhead Golf Course	15	0.2	0.037	1.9	1.9	bd	0.003	0.003	0.004	0.006	0.002	bd	bd	12	7	3	3	bd
7	**Village of Keephills**	15	0.3	0.033	1.9	1.9	bd	0.003	0.004	0.005	0.009	0.002	bd	bd	21	13	3	3	bd
			Maximum 1-hour average																
1	Carvel	9	0.8	0.069	2.7	2.6	0.1	0.016	0.021	0.021	0.042	0.011	0.002	0.001	74	43	5	4	5
2	**Alberta Beach**	15	0.7	0.062	2.6	2.6	0.1	0.013	0.025	0.028	0.042	0.005	0.002	0.002	146	84	13	10	14
3	Darwell	6	0.3	0.038	2.1	2.2	0.1	0.015	0.013	0.010	0.022	0.005	0.001	bd	19	16	6	5	4
4	**Seba Beach**	15	2.8	0.062	2.7	2.6	0.1	0.006	0.040	0.020	0.059	0.007	0.002	bd	41	23	5	4	10
5	Wabamun	15	1.1	0.055	2.5	2.5	0.1	0.020	0.049	0.022	0.070	0.007	0.001	0.001	43	28	5	3	6
6	**Ironhead Golf Course**	15	0.6	0.058	2.5	2.5	0.1	0.036	0.019	0.014	0.033	0.011	0.002	bd	127	81	16	12	2
7	Village of Keephills	15	0.9	0.047	3.0	3.0	0.3	0.017	0.016	0.015	0.027	0.009	0.002	0.001	212	136	17	13	11
AAAQO			13.0	0.082	n/a	n/a	n/a	0.172	n/a	0.212	n/a	2.000	n/a	0.010	n/a	n/a	n/a	n/a	n/a

Notes:

bd = below detection limit **ND** - no data *****=monitored for part of the study **ppm** = parts per million **ng/m^3** = nanograms per cubic meter **$\mu g/m^3$** = micrograms per cubic meter

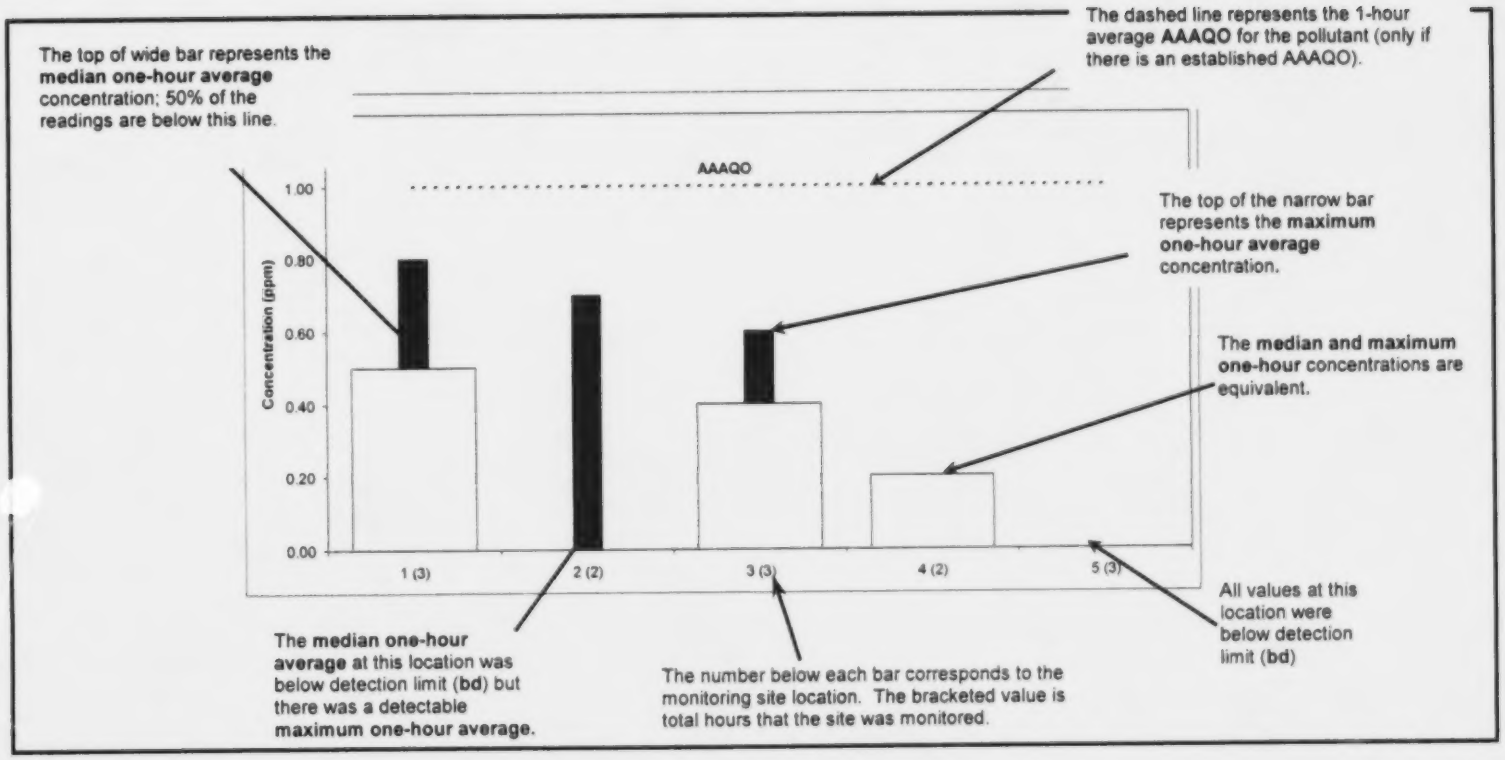
The top of wide bar represents the **median one-hour average** concentration; 50% of the readings are below this line.
The dashed line represents the 1-hour average **AAAQO** for the pollutant (only if there is an established AAAQO).
AAAQO
1.00
0.80
0.60
0.40
0.20
0.00
Concentration (ppm)
The top of the narrow bar represents the **maximum one-hour average** concentration.
The **median and maximum one-hour** concentrations are equivalent.
1 (3)
2 (2)
3 (3)
4 (2)
5 (3)
All values at this location were below detection limit (**bd**)
The **median one-hour average** at this location was below detection limit (**bd**) but there was a detectable **maximum one-hour average.**
The number below each bar corresponds to the monitoring site location. The bracketed value is total hours that the site was monitored.

Figure 2: A key for interpreting the figures presenting median and maximum one-hour averages.

3.1. Oxides of Nitrogen

Nitrogen dioxide (NO_2) and nitric oxide (NO) are known as oxides of nitrogen (NO_x). NO_x and volatile organic compounds (VOCs) play a major role in the formation of ground level ozone. In Alberta, transportation (automobiles, locomotives and aircraft) is the major source of NO_x, however there are other sources including power plants and the oil and gas industries. In some areas these may be significant sources of NO_x. Although both NO and NO_2 are emitted by high temperature combustion processes as in fossil fuel combustion, NO is readily converted in the atmosphere into NO_2 through reaction with O_3. In the presence of solar radiation, NO_2 can be converted back to NO thorough photolysis.

Alberta has a one-hour ambient air quality objective for NO_2 of 0.212 parts per million (ppm). The median one-hour average NO_x concentrations at the seven sites were comparable ranging from 0.006 to 0.008 ppm. The median one-hour average NO_x concentrations for the 2000/01 study were similar with the exception of the median concentration at Alberta Beach which was lower at 0.003 ppm (Table A4). For the current study, NO_2 composed 64% of NO_x on average. One-hour average NO_2 concentrations ranged from below detection limit (bd) to 0.028 ppm and Alberta's ambient objective of 0.212 ppm was not exceeded. NO_2 concentrations for this study were comparable to concentrations measured during other MAML studies conducted in rural areas or small communities (Table A1). Furthermore, NO_2 concentrations measured in the Wabamun area were similar to concentrations observed at semi-rural permanent monitoring stations. For example the median one-hour average concentration for 2007 at Beaverlodge (~ 30 km east of Grand Prairie) was 0.003 ppm.

Figure 3 illustrates that the maximum one-hour NO_x concentrations at most of the sites were notably higher than the median values. On average, NO contribution to NO_x was 36%. However for the top 25% of NO_x concentrations (such as the maximums shown in Figure 3), NO fraction was higher, on average 50%. Elevated NO concentrations (greater than 0.024 ppm) were determined for Sites 2, 4 and 5 (Alberta Beach, Seba Beach and Wabamun). These concentrations were observed for periods with low wind speed and may have been influenced by local vehicle exhaust. One-hour average NO concentrations ranged from below detection limit to 0.049 ppm.

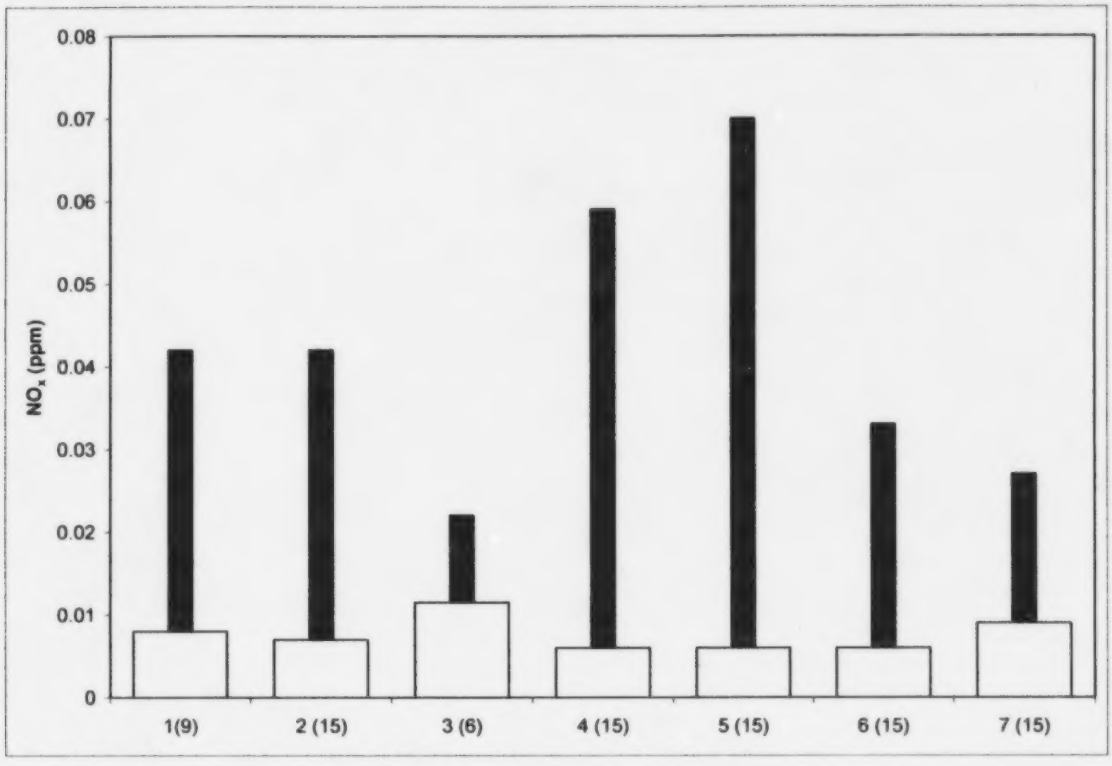

Figure 3: Median and maximum one-hour concentrations for oxides of nitrogen.

3.2. *Sulphur Dioxide (SO_2)*

In Alberta, upstream oil and gas industry[2] are responsible for close to half of the SO_2 emissions in the province. Power plants and oil sands facilities can also be SO_2 sources in some areas. Other sources include gas plant flares, oil refineries, pulp and paper mills and fertilizer plants.

As illustrated in Figure 4, one-hour average SO_2 concentrations for the current study were lower than the ambient air quality objective of 0.172 ppm. Median one-hour average SO_2 concentrations at all but one site were 0.003 ppm. The exception was **Site 3** (Darwell)[3] where the concentration was 0.005 ppm. Much like NO_x, SO_2 concentrations in general did not vary notably between most sites. This being said, SO_2 concentrations up to ten times higher than the

[2] "Upstream oil and gas industry includes the exploration, production and basic processing of crude oil and natural gas." http://www.ec.gc.ca/cleanair-airpur/Upstream_Oil_and_Gas-WSEBE19790-1_En.htm

[3] Note that Site 3 also had a smaller number of samples (see Figure 4)

median to concentrations were observed (Figure 4 and Table 2). The maximum one-hour average concentration of 0.036 ppm for the study was measured at Ironhead Golf course (**Site 6**).

The median one-hour average SO_2 concentration for other MAML studies ranged from 0.001 to 0.003 ppm. The upper limit of this range is equivalent to the median one-hour average concentrations determined for most monitoring sites for the current study. Median one-hour average SO_2 concentration for the 2000/01 study ranged from below detection limit to 0.003 ppm (Table A4).

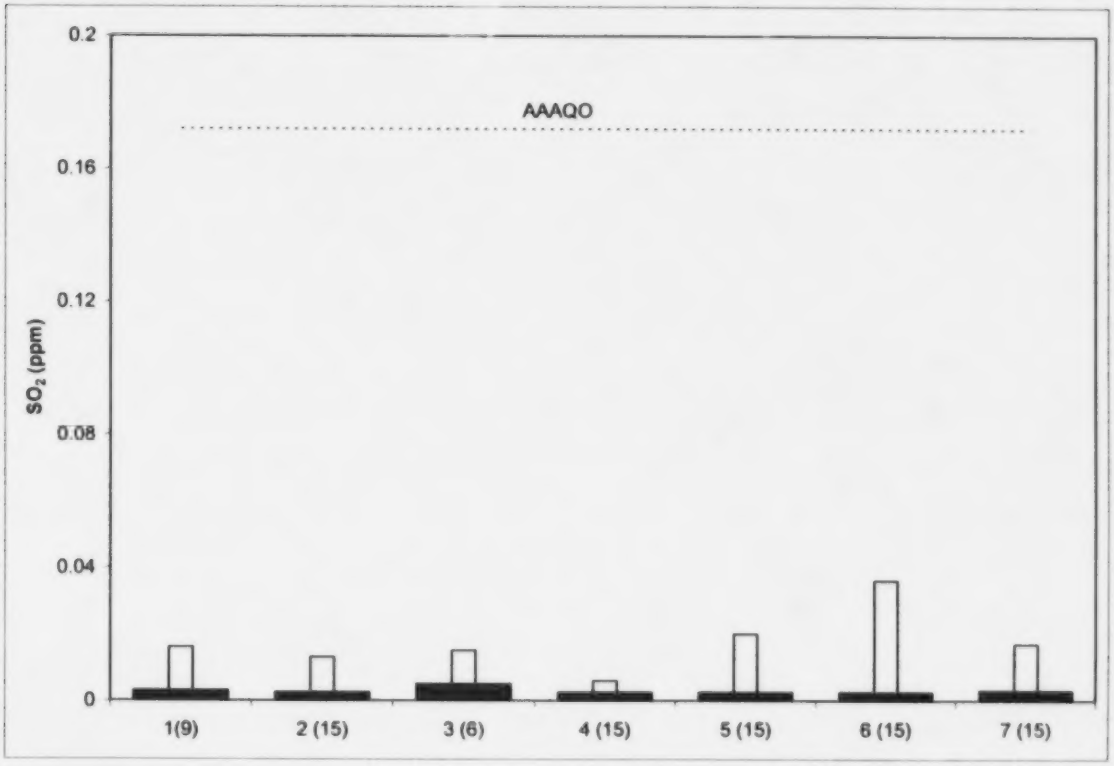

Figure 4: Median and maximum one-hour average concentrations for sulphur dioxide.

3.3. *Ozone (O_3)*

Ozone (O_3) is a major component of smog. In the lower atmosphere, it is formed through chemical reactions involving nitrogen dioxide (NO_2) and volatile organic compounds (VOCs) in the presence of sunlight. Ozone levels are typically higher during the spring and summer months likely due to spring time stratospheric intrusion and more readily available solar radiation during the summer.

Alberta has a one-hour air quality objective of 0.082 ppm for O_3. One-hour average ozone concentrations measured during the current survey were below this objective. The median and maximum one-hour O_3 concentrations are presented in Figure 5. Median one-hour average concentrations at all seven monitoring sites were below 0.040 ppm. The maximum one-hour average concentrations ranged from 0.038 to 0.069 ppm. O_3 concentrations greater than 0.037 ppm were largely (65% of the time) measured during the spring sample periods. Concentrations measured during the 2000/01 study were similar to the current study with maximum one-hour average concentrations at the various sites ranging from 0.038 to 0.057 ppm (Table A4). Concentrations measured during the current study were most comparable to concentrations measured during the *Fort Saskatchewan* and *Caroline* MAML studies (Table A1).

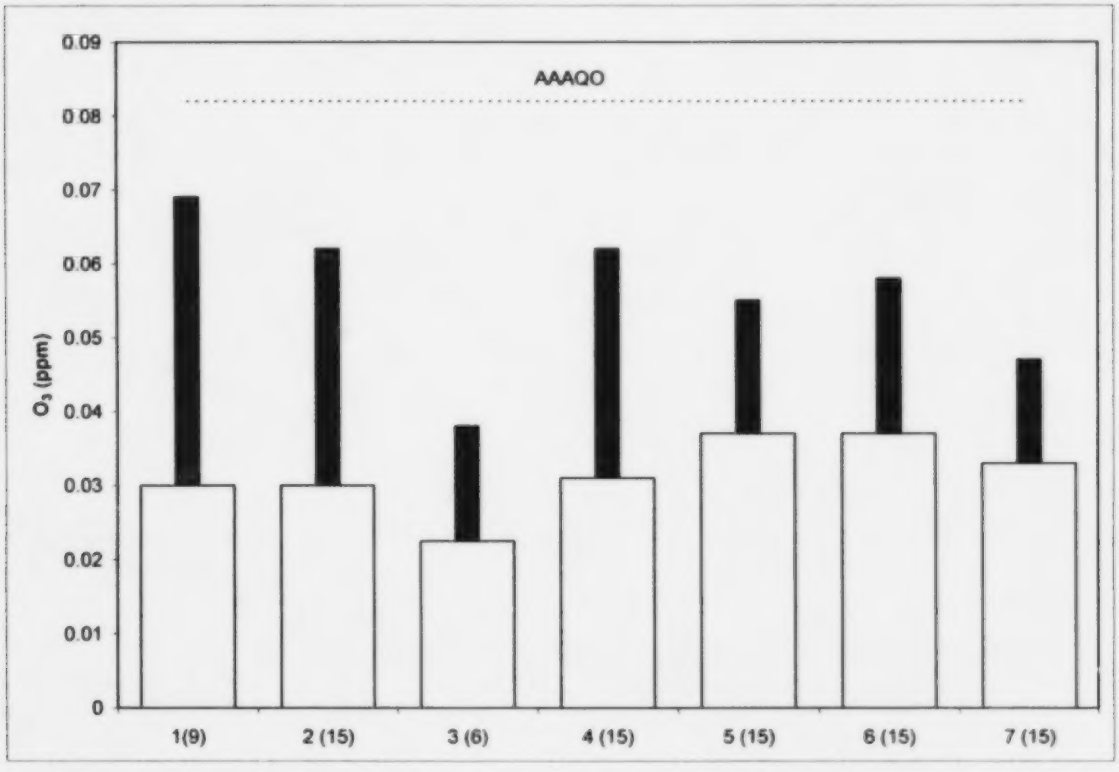

Figure 5: Median and maximum one-hour average concentrations for ozone.

3.4. Particulate Matter

Inhalable particulates are particulate matter less than 10 micrometres (μm) in aerodynamic diameter (PM_{10}). These particles can be inhaled into the nose and throat. Sources of PM_{10} include soil dust, road dust, agricultural dust (e.g., harvest), smoke from forest fires and wood burning, vehicle exhaust and industrial emissions. Respirable particulates are those particulate matter less than 2.5 μm ($PM_{2.5}$) in aerodynamic diameter. These particles are small enough to penetrate into the lungs. Respirable particulates may form in the atmosphere and/or arise from combustion sources such as vehicle exhaust, industrial emissions and wood burning. In addition to PM_{10} and $PM_{2.5}$, total suspended particles (TSP) and PM_1 (particles less than 1 μm in aerodynamic diameter) were also measured for a portion of the study. TSP range in size from 0.001 to 500 μm; this group includes PM_{10}, $PM_{2.5}$ and PM_1. Although not included in the discussion to follow, concentrations of TSP and PM_1 are presented in Table 2.

One-hour average $PM_{2.5}$ concentrations measured during this study were lower than the one-hour average guideline of 80 $\mu g/m^3$. Median one-hour average concentrations at the seven sites ranged from 3 to 5 $\mu g/m^3$. As indicated in Figure 6 the maximum concentrations at **Sites 2, 6** and **7** were relatively higher than at other sites. Typically, one-hour average $PM_{2.5}$ concentrations greater than 10 $\mu g/m^3$ were observed concurrently with elevated NO_x or SO_2 concentrations.

On average $PM_{2.5}$ formed 29% of PM_{10}. This indicates that the PM_{10} mass concentration measured at the seven monitoring sites contained a large mass fraction from particles with diameter greater than 2.5 micrometer (μm). Median one-hour average PM_{10} concentrations measured during the current survey ranged from 7 to 13 $\mu g/m^3$ (Figure 7). The maximum one-hour average for the study of 136 $\mu g/m^3$ was measured at Keephills (**Site 7**) at a time when the wind speed was less than 2 km/hr. Such an elevated concentration is likely due to reduced dispersion of local vehicle emission.

While $PM_{2.5}$ concentrations measured during the 2000/01 study were comparable to the current, PM_{10} concentrations were considerable higher. The maximum one-hour average concentration for the 2000/01 study was 534 $\mu g/m^3$ (Table A4). Some of the elevated concentrations during the earlier study is likely due to wind blown dust.

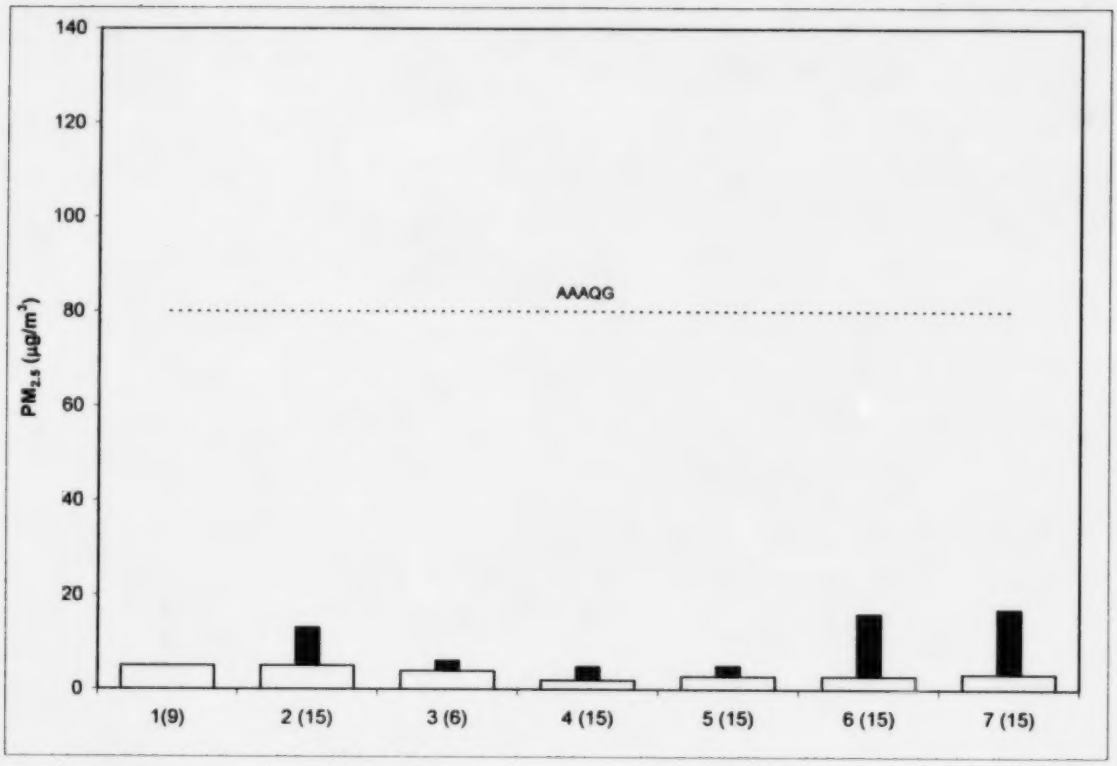

Figure 6: Median and maximum one-hour average concentrations for $PM_{2.5}$. To facilitate comparison the y-axis is set equivalent to that in Figure 7.

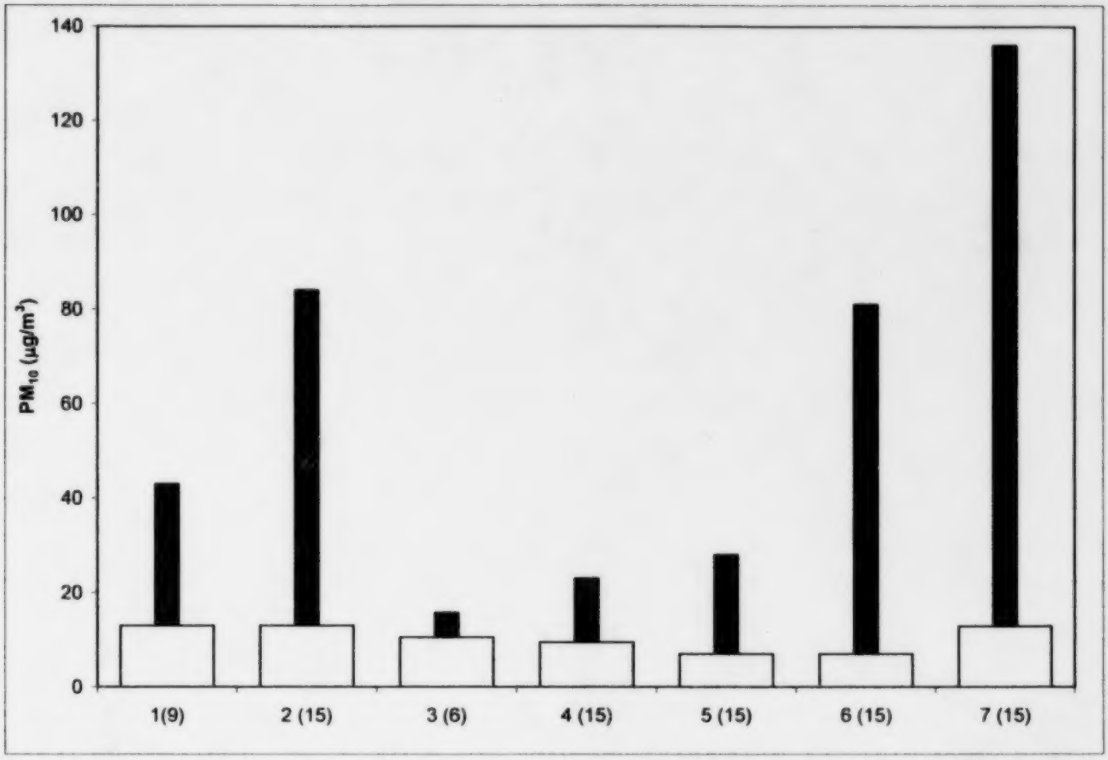

Figure 7: Median and maximum one-hour average concentrations for PM_{10}.

3.5. Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons are organic compounds consisting of two or more benzene rings and are formed through incomplete combustion. There are more than 100 different PAHs with varying levels of toxicity. Ambient sources of PAHs include vehicle exhaust, wood smoke from residential and industrial use and forest fires. PAHs occur as complex mixtures and can be found as a gas or condensed onto particles. The phase of PAHs is dependant on ambient conditions such as temperature and the molecular structure of the compound. Larger PAHs (containing more benzene rings) tend to be found in the condensed phase (bound onto particles). It is these types of PAHs that are measured by the MAML.

With the exception of two surveys, median PAHs concentrations measured during other MAML surveys were typically below the detection limit of the instrument on board (3 ng/m^3). The median one-hour average concentrations for recent MAML surveys are presented in Table A1. Although a maximum one-hour average PAHs concentration up to 14 ng/m^3 was observed for the current survey, the median one-hour average PAHs concentrations at the various

sites were below the detection limit of the instrument on board the MAML. Figure 8 illustrates the maximum one-hour average concentration at the seven monitoring sites. Concentrations above 8 ng/m^3 were typically observed for wind speeds lower than 2 km/hr, and are likely due to the local traffic emissions. The results for the 2000/01 study were very similar with below detection limit median one-hour average concentrations (Table A4).

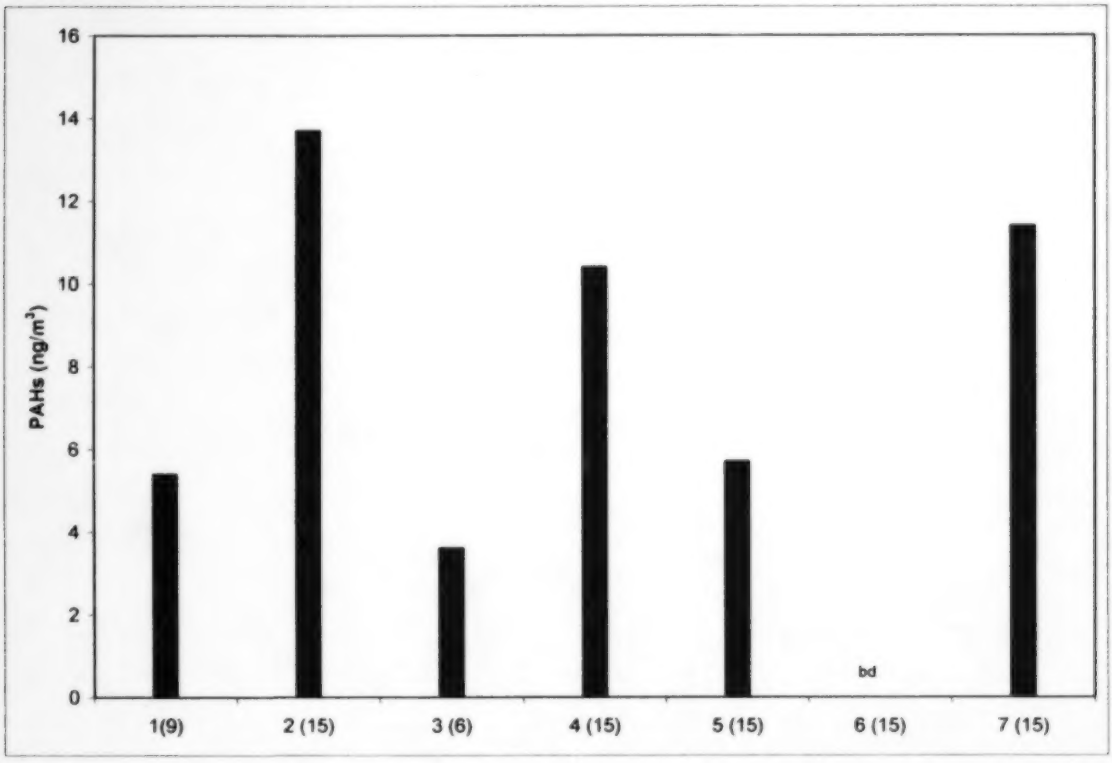

Figure 8: Maximum one-hour PAHs concentrations. Median one-hour average concentrations at all of the sites were below detection limit.

Appendix A

Table A1: Median one-hour average concentrations measured at selected MAML surveys and permanent monitoring stations.

Station or Survey Type	Air Quality Station or Survey Name	Monitoring Period	CO ppm	O_3 ppm	THC ppm	CH_4 ppm	RHC ppm	SO_2 ppm	NO_2 ppm	NH_3 ppm	TRS ppm	H_2S ppm	TSP µg/m³	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	PM_1 µg/m³	PAH ng/m³
mobile	Wabamun (Current)	Nov 2004 - Oct 2007	0.2	0.032	2.0	2.0	bd	0.003	0.005	0.001	bd	bd	17*	12	3	4*	bd
	Fort Saskatchewan and Redwater Area	Jan 2006 - Nov 2007	0.2	0.030	1.9	1.9	bd	0.003	0.004	0.003	bd	bd	17*	10	3	7*	bd
	Slave Lake	**Dec 2005 -Mar 2006**	**0.2**	**0.003**	**2.4**	**2.4**	**bd**	**0.001**	**0.012**	**bd**	**0.001**	**bd**	**18**	**13**	**5**	**n/a**	**8**
	Calder Yards Edmonton	Mar 2005	0.7	0.010	2.7	2.5	0.3	0.002	0.033	0.008	0.001	0.001	43	28	4	n/a	20
	Tolko High Prairie	**Dec 2005 -Mar 2006**	**0.2**	**0.018**	**2.0**	**1.9**	**bd**	**0.001**	**0.005**	**bd**	**0.001**	**bd**	**16**	**12**	**3**	**n/a**	**bd**
	Caroline	Oct 05 & Jan, May, Jun 06	0.2	0.038	1.8	1.8	bd	0.002	0.004	0.003	0.001	0.001	79	49	6	n/a	bd
	Girouxville	**Fall 2004, spring 2005, 2006**	**0.3**	**0.028**	**2.1**	**2.1**	**bd**	**0.001**	**0.001**	**0.013**	**0.002**	**0.001**	**21**	**15**	**2**	**n/a**	**bd**
	Whitecourt	Sep. 6 - 7, 2005	0.2	0.027	2.1	2.1	bd	0.001	0.002	0.084	0.001	0.001	28	16	2	n/a	bd
Permanent Continuous Monitoring Stations																	
urban	Calgary Central	Jan 07 - Dec 07	0.3	0.016	2.0	n/a	n/a	n/a	0.021	n/a	n/a	n/a	n/a	20	4	n/a	n/a
	Edmonton Central	**Jan 07 - Dec 07**	**0.3**	**0.017**	**2.0**	**n/a**	**n/a**	**n/a**	**0.016**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**4**	**n/a**	**n/a**
semi-urban	Beverlodge	Jan 07 - Dec 07	n/a	0.029	n/a	n/a	n/a	bd	0.003	n/a	n/a	n/a	n/a	n/a	2	n/a	n/a
	Henry Pirker	**Jan 07 - Dec 07**	**0.2**	**0.023**	**2.1**	**n/a**	**n/a**	**bd**	**0.006**	**n/a**	**bd**	**n/a**	**n/a**	**n/a**	**3**	**n/a**	**n/a**
Industrial	Mannix	Jan 07 - Dec 07	n/a	n/a	1.9	n/a	n/a	bd	n/a	n/a	n/a	0.001	n/a	n/a	n/a	n/a	n/a
	Mildred Lake	**Jan 07 - Dec 07**	**n/a**	**n/a**	**2.0**	**n/a**	**n/a**	**0.001**	**n/a**	**n/a**	**n/a**	**bd**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**

Notes:

bd = below detection limit **ND** - no data ***=monitored for part of the study **ppm** = parts per million **ng/m³** = nanograms per cubic meter **µg/m³** = micrograms per cubic meter

Table A2: One-hour average concentrations at the various monitoring times and locations

Location	Date	Sample Times	CO PPM	O_3 PPM	THC PPM	CH_4 PPM	RHC PPM	SO_2 PPM	NO PPM	NO_2 PPM	NO_x PPM	NH_3 PPM	TRS PPM	H_2S PPM	TSP µg/m³	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	PM_1 µg/m³	PAH ng/m³
Carvel	11/18/2004	09:18 to 10:18	0.1	0.010	2.7	2.6	0.1	bd	0.004	0.01	0.014	0.001	0.001	0.001	50	32	5	ND	bd
	6/22/2005	**16:52 to 17:52**	**0.4**	**0.030**	**2.2**	**2.3**	**bd**	**0.001**	**0.005**	**0.005**	**0.006**	**0.001**	**bd**	**bd**	**12**	**8**	**1**	**ND**	**bd**
	2/17/2006	10:05 to 11:05	0.3	0.033	2.0	2.0	bd	0.003	0.004	0.006	0.008	bd	0.002	bd	17	13	5	ND	4.1
	5/5/2006	**09:11 to 10:15**	**0.1**	**0.035**	**1.8**	**1.8**	**bd**	**0.004**	**bd**	**0.006**	**0.004**	**0.011**	**0.001**	**bd**	**ND**	**ND**	**ND**	**ND**	**bd**
	5/8/2006	15:34 to 16:36	0.2	0.045	1.7	1.7	bd	0.001	0.004	0.006	0.009	0.004	0.001	bd	74	43	5	ND	bd
	12/13/2006	**10:28 to 11:27**	**0.8**	**0.024**	**2.0**	**1.9**	**0.1**	**0.004**	**0.014**	**0.011**	**0.024**	**0.005**	**bd**	**0.001**	**6**	**4**	**1**	**ND**	**3.2**
	12/14/2006	15:19 to 16:19	0.5	0.016	2.0	2.0	bd	0.004	0.021	0.021	0.042	0.001	bd	bd	27	22	5	ND	5.4
Alberta Beach	**5/31/2007**	**16:12 to 17:01**	**0.3**	**0.069**	**1.9**	**1.9**	**bd**	**0.016**	**0.002**	**0.005**	**0.006**	**0.004**	**bd**	**bd**	**ND**	**ND**	**ND**	**ND**	**bd**
	8/28/2007	07:55 to 08:59	0.2	0.012	2.0	2.0	bd	0.003	0.003	0.001	0.004	bd	bd	bd	ND	8	5	3.7	bd
	11/16/2004	**15:09 to 16:09**	**0.2**	**0.024**	**2.1**	**2.2**	**bd**	**0.001**	**0.001**	**0.004**	**0.005**	**bd**	**bd**	**bd**	**12**	**7**	**1**	**ND**	**bd**
	11/18/2004	10:40 to 11:40	0.1	0.011	2.6	2.6	bd	0.001	0.004	0.01	0.014	bd	bd	bd	57	37	5	ND	bd
	6/22/2005	**15:31 to 16:31**	**0.2**	**0.034**	**2.2**	**2.3**	**bd**	**bd**	**0.003**	**0.004**	**0.003**	**bd**	**0.001**	**bd**	**58**	**36**	**3**	**ND**	**bd**
	10/5/2005	09:16 to 10:16	0.1	0.017	2.0	2.0	bd	0.001	0.003	0.003	0.006	bd	0.001	0.002	14	9	2	ND	bd
	2/17/2006	**16:49 to 17:49**	**0.2**	**0.034**	**1.9**	**1.9**	**bd**	**0.002**	**0.025**	**0.018**	**0.042**	**0.005**	**0.001**	**bd**	**38**	**25**	**6**	**ND**	**13.7**
	3/8/2006	09:59 to 10:57	0.2	0.036	ND	ND	ND	0.004	0.003	0.006	0.009	0.004	0.001	0.001	7	3	1	ND	bd
	5/5/2006	**16:03 to 17:04**	**0.2**	**0.062**	**1.7**	**1.7**	**bd**	**0.004**	**0.003**	**0.004**	**0.006**	**0.005**	**0.002**	**bd**	**ND**	**ND**	**ND**	**ND**	**bd**
	5/8/2006	14:08 to 15:08	0.3	0.052	1.7	1.7	bd	bd	0.004	0.001	0.005	0.005	bd	bd	146	84	8	ND	bd
	12/13/2006	**17:18 to 18:19**	**0.7**	**0.007**	**2.2**	**2.2**	**bd**	**0.002**	**0.009**	**0.028**	**0.036**	**0.004**	**bd**	**bd**	**17**	**13**	**3**	**ND**	**8.3**
	12/14/2006	13:55 to 14:57	0.3	0.030	1.9	1.9	bd	0.004	0.006	0.01	0.016	0.002	bd	bd	21	15	5	ND	bd
	5/25/2007	**08:40 to 09:42**	**0.1**	**0.030**	**2.0**	**2.0**	**bd**	**0.013**	**0.004**	**0.005**	**0.008**	**bd**	**bd**	**bd**	**ND**	**7**	**6**	**5**	**bd**
	5/31/2007	13:55 to 14:55	0.5	0.062	1.9	1.9	bd	0.004	0.002	0.003	0.004	0.004	bd	bd	ND	ND	ND	ND	bd
	8/28/2007	**09:21 to 10:21**	**0.2**	**0.022**	**2.0**	**1.9**	**bd**	**0.003**	**0.003**	**0.002**	**0.005**	**bd**	**bd**	**bd**	**ND**	**12**	**6**	**4.9**	**bd**
	8/29/2007	08:11 to 09:17	0.2	0.016	2.1	2.1	bd	ND	0.004	0.004	0.007	bd	bd	bd	ND	11	6	5.4	bd
	10/12/2007	**08:21 to 09:22**	**0.3**	**0.009**	**2.3**	**2.2**	**0.1**	**0.008**	**0.011**	**0.01**	**0.02**	**0.001**	**bd**	**bd**	**ND**	**31**	**13**	**9.6**	**10.2**
Darwell	11/16/2004	13:49 to 14:49	0.2	0.025	2.1	2.2	bd	0.001	0.001	0.003	0.005	bd	bd	bd	13	8	1	ND	bd
	10/5/2005	**10:32 to 11:33**	**0.1**	**0.012**	**2.0**	**2.0**	**bd**	**0.015**	**0.013**	**0.01**	**0.022**	**bd**	**bd**	**bd**	**19**	**13**	**3**	**ND**	**bd**
	3/8/2006	11:14 to 12:15	0.2	0.038	1.9	1.9	bd	0.005	0.004	0.007	0.01	0.005	0.001	bd	17	10	2	ND	bd
	5/25/2007	**09:59 to 11:00**	**0.1**	**0.031**	**1.9**	**1.9**	**bd**	**0.014**	**0.006**	**0.008**	**0.013**	**bd**	**bd**	**bd**	**ND**	**11**	**6**	**4**	**bd**
	8/29/2007	09:39 to 10:42	0.3	0.020	2.1	2.1	0.1	ND	0.005	0.005	0.009	bd	bd	bd	ND	10	5	3.8	bd
	10/12/2007	**09:38 to 10:38**	**0.3**	**0.017**	**2.1**	**2.1**	**bd**	**0.001**	**0.008**	**0.008**	**0.016**	**0.002**	**bd**	**bd**	**ND**	**16**	**6**	**4.6**	**3.6**

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Notes:

bd = below detection limit **ND** - no data **ppm** = parts per million **ng/m³** = nanograms per cubic meter **µg/m³** = micrograms per cubic meter

Table A2 continued from previous page: One-hour average concentrations at the various monitoring times and locations

Location	Date	Sample Times	CO PPM	O_3 PPM	THC PPM	CH_4 PPM	RHC PPM	SO_2 PPM	NO PPM	NO_2 PPM	NO_x PPM	NH_3 PPM	TRS PPM	H_2S PPM	TSP µg/m³	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	PM_1 µg/m³	PAH ng/m³
Seba Beach	11/16/2004	12:27 to 13:27	0.3	0.024	2.2	2.2	bd	0.002	0.002	0.004	0.006	bd	bd	bd	11	7	2	ND	bd
	11/18/2004	12:13 to 13:13	0.2	0.010	2.6	2.6	bd	bd	0.008	0.013	0.02	bd	bd	bd	38	23	3	ND	6.5
	6/22/2005	14:00 to 15:00	0.1	0.036	2.2	2.2	bd	bd	0.002	0.004	0.003	0.001	0.002	bd	21	12	1	ND	bd
	10/5/2005	11:50 to 12:51	0.1	0.024	2.0	2.0	bd	0.001	0.004	0.003	0.004	bd	0.001	bd	41	22	2	ND	bd
	2/17/2006	15:12 to 16:12	0.2	0.040	1.9	1.9	bd	0.001	0.002	0.004	0.005	bd	0.001	bd	14	9	1	ND	bd
	3/8/2006	12:32 to 13:33	0.2	0.039	1.9	1.9	bd	0.004	0.003	0.007	0.01	0.004	bd	bd	14	7	1	ND	bd
	5/5/2006	14:27 to 15:26	0.3	0.057	1.7	1.7	bd	0.004	0.006	0.007	0.011	0.006	0.002	bd	ND	ND	ND	ND	bd
	5/8/2006	12:36 to 13:36	0.4	0.051	1.7	1.7	bd	bd	0.002	0.002	0.004	0.005	bd	bd	27	18	3	ND	bd
	12/13/2006	15:37 to 16:37	2.8	0.008	2.7	2.6	0.1	0.003	0.04	0.02	0.059	0.007	bd	bd	19	13	2	ND	10.4
	12/14/2006	12:19 to 13:22	0.5	0.015	2.2	2.2	bd	0.003	0.025	0.018	0.043	0.001	bd	bd	9	6	1	ND	bd
	5/25/2007	11:18 to 12:20	0.1	0.042	1.9	1.9	bd	0.004	0.001	0.002	0.002	bd	bd	bd	ND	7	4	3	bd
	5/31/2007	12:22 to 13:22	0.2	0.062	1.9	1.9	bd	0.005	0.001	0.002	0.002	0.004	bd	bd	ND	ND	ND	ND	bd
	8/28/2007	10:54 to 11:55	0.2	0.028	1.9	1.9	0.1	0.006	0.007	0.006	0.012	0.001	bd	bd	ND	12	5	3.6	bd
	8/29/2007	11:02 to 12:10	0.3	0.026	2.0	2.0	bd	ND	0.006	0.003	0.008	0.001	bd	bd	ND	9	4	3.4	bd
	10/12/2007	10:54 to 11:56	0.2	0.031	1.9	1.9	bd	0.001	0.001	0.005	0.006	bd	0.001	bd	ND	10	4	2.7	bd
Wabamun	11/16/2004	11:07 to 12:07	0.3	0.024	2.2	2.3	bd	0.001	0.003	0.005	0.008	bd	bd	bd	18	10	1	ND	bd
	11/18/2004	13:32 to 14:32	0.1	0.011	2.5	2.5	bd	bd	0.007	0.012	0.019	0.001	bd	bd	43	28	5	ND	5.7
	6/22/2005	12:38 to 13:38	0.2	0.037	2.2	2.2	bd	bd	0.002	0.004	0.003	0.001	0.001	bd	11	8	1	ND	bd
	10/5/2005	13:12 to 14:12	0.1	0.026	2.0	2.0	bd	0.002	0.002	0.002	0.004	bd	0.001	0.001	17	11	2	ND	bd
	2/17/2006	13:53 to 14:53	0.2	0.039	1.9	1.9	bd	0.003	0.004	0.006	0.008	bd	0.001	bd	20	13	2	ND	bd
	3/8/2006	13:57 to 14:55	0.2	0.045	1.7	1.8	bd	0.003	0.003	0.006	0.009	0.005	bd	bd	9	5	1	ND	4.7
	5/5/2006	13:07 to 14:08	0.1	0.055	1.7	1.7	bd	0.008	0.001	0.005	0.004	0.005	0.001	bd	ND	ND	ND	ND	bd
	5/8/2006	11:15 to 12:18	0.7	0.049	1.7	1.7	bd	0.001	0.003	0.002	0.005	0.004	bd	bd	30	19	3	ND	bd
	12/13/2006	14:16 to 15:18	0.9	0.023	2.1	2.0	0.1	0.003	0.011	0.012	0.022	0.005	bd	bd	8	5	1	ND	3.6
	12/14/2006	10:59 to 12:01	1.1	0.012	2.3	2.3	bd	0.002	0.049	0.022	0.07	0.004	bd	bd	13	8	3	ND	4.7
	5/25/2007	12:36 to 13:37	0.2	0.040	1.9	1.9	bd	0.011	0.003	0.005	0.007	bd	bd	bd	ND	6	4	3	bd
	5/31/2007	11:04 to 12:04	0.2	0.046	2.0	2.0	bd	0.02	0.005	0.01	0.013	0.007	bd	bd	ND	ND	ND	ND	bd
	8/28/2007	12:13 to 13:12	0.2	0.036	1.9	1.9	bd	0.004	0.002	0.002	0.003	bd	bd	bd	ND	8	4	3.2	bd
	8/29/2007	15:31 to 16:31	0.4	0.035	1.9	1.9	bd	ND	0.006	0.008	0.012	0.001	bd	bd	ND	9	3	1.8	bd
	10/12/2007	12:13 to 13:14	0.3	0.028	2.1	2.1	bd	0.001	0.009	0.006	0.012	0.001	bd	bd	ND	27	4	2.4	bd

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Notes:

bd = below detection limit **ND** - no data **ppm** = parts per million **ng/m³** = nanograms per cubic meter **µg/m³** = micrograms per cubic meter

Table A2 continued from previous page: One-hour average concentrations at the various monitoring times and locations

Location	Date	Sample Times	CO PPM	O_3 PPM	THC PPM	CH_4 PPM	RHC PPM	SO_2 PPM	NO PPM	NO_2 PPM	NO_x PPM	NH_3 PPM	TRS PPM	H_2S PPM	TSP µg/m³	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	PM_1 µg/m³	PAH ng/m³
Ironhead Golf Course	11/16/2004	09:46 to 10:46	0.3	0.016	2.2	2.3	bd	0.001	0.002	0.004	0.006	0.011	bd	bd	7	3	1	ND	bd
	11/18/2004	**14:44 to 15:44**	**0.1**	**0.013**	**2.5**	**2.5**	**bd**	**bd**	**0.003**	**0.014**	**0.016**	**bd**	**bd**	**bd**	**13**	**10**	**3**	**ND**	**bd**
	6/22/2005	11:28 to 12:28	0.3	0.033	2.2	2.2	bd	bd	0.004	0.005	0.006	0.002	0.002	bd	25	13	2	ND	bd
	10/5/2005	**14:29 to 15:30**	**0.1**	**0.025**	**2.0**	**2.0**	**bd**	**0.004**	**0.004**	**0.003**	**0.006**	**bd**	**0.001**	**bd**	**62**	**41**	**5**	**ND**	**bd**
	2/17/2006	12:41 to 13:41	0.2	0.038	1.9	1.9	bd	0.001	0.003	0.004	0.005	bd	0.001	bd	10	7	1	ND	bd
	3/8/2006	**15:07 to 16:05**	**0.1**	**0.048**	**1.7**	**1.7**	**bd**	**0.004**	**bd**	**0.006**	**0.006**	**0.004**	**0.001**	**bd**	**9**	**6**	**1**	**ND**	**bd**
	5/5/2006	11:50 to 12:54	0.1	0.058	1.7	1.7	bd	0.003	bd	0.003	bd	0.005	0.002	bd	ND	ND	ND	ND	bd
	5/8/2006	**10:01 to 11:01**	**0.1**	**0.050**	**1.7**	**1.7**	**bd**	**bd**	**0.003**	**0.001**	**0.003**	**0.004**	**bd**	**bd**	**127**	**81**	**10**	**ND**	**bd**
	12/13/2006	13:05 to 14:05	0.6	0.026	1.9	1.9	bd	0.003	0.009	0.009	0.016	0.005	bd	bd	12	6	1	ND	bd
	12/14/2006	**09:47 to 10:47**	**0.6**	**0.017**	**2.1**	**2.1**	**0.1**	**0.002**	**0.019**	**0.014**	**0.033**	**0.001**	**bd**	**bd**	**7**	**4**	**1**	**ND**	**bd**
	5/25/2007	13:48 to 14:49	0.2	0.041	1.9	1.9	bd	0.009	0.002	0.005	0.006	bd	bd	bd	ND	5	4	3	bd
	5/31/2007	**09:48 to 10:47**	**0.2**	**0.046**	**2.0**	**2.0**	**bd**	**0.036**	**0.002**	**0.003**	**0.004**	**0.009**	**bd**	**bd**	**ND**	**36**	**16**	**12**	**bd**
	8/28/2007	13:22 to 14:23	0.2	0.040	1.9	1.8	bd	0.009	0.002	bd	0.001	bd	bd	bd	ND	5	3	2.7	bd
	8/29/2007	**14:06 to 15:16**	**0.3**	**0.030**	**1.8**	**1.8**	**bd**	**ND**	**0.007**	**0.006**	**0.012**	**bd**	**bd**	**bd**	**ND**	**7**	**3**	**1.5**	**bd**
	10/12/2007	13:27 to 14:28	0.3	0.037	1.9	1.9	bd	0.001	0.002	0.002	0.003	0.004	bd	bd	ND	19	6	3.6	bd
Keephills	**11/16/2004**	**08:22 to 09:22**	**0.4**	**0.011**	**2.4**	**2.5**	**bd**	**0.002**	**0.012**	**0.004**	**0.014**	**0.003**	**bd**	**bd**	**11**	**7**	**1**	**ND**	**bd**
	11/18/2004	16:10 to 17:10	0.6	0.002	3.0	3.0	0.1	bd	0.016	0.012	0.027	0.001	bd	bd	212	136	13	ND	11.4
	6/22/2005	**10:04 to 11:04**	**0.3**	**0.033**	**2.3**	**2.3**	**bd**	**0.001**	**0.001**	**0.003**	**0.001**	**0.004**	**0.001**	**0.001**	**16**	**10**	**1**	**ND**	**bd**
	10/5/2005	15:48 to 16:49	0.9	0.024	2.1	2.0	0.1	0.004	0.004	0.002	0.005	0.002	bd	0.001	34	21	3	ND	bd
	2/17/2006	**11:23 to 12:23**	**0.3**	**0.037**	**2.2**	**2.0**	**0.3**	**0.003**	**0.006**	**0.005**	**0.01**	**bd**	**0.002**	**bd**	**21**	**13**	**4**	**ND**	**3.6**
	3/8/2006	16:25 to 17:25	0.2	0.043	1.7	1.7	bd	0.003	0.001	0.008	0.009	0.003	bd	bd	12	7	1	ND	bd
	5/5/2006	**10:31 to 11:33**	**0.1**	**0.037**	**1.7**	**1.7**	**bd**	**0.017**	**0.007**	**0.012**	**0.017**	**0.006**	**bd**	**bd**	**ND**	**ND**	**ND**	**ND**	**bd**
	5/8/2006	08:44 to 09:43	0.1	0.047	1.7	1.7	bd	bd	0.002	0.002	0.004	0.004	0.001	bd	97	57	6	ND	bd
	12/13/2006	**11:45 to 12:45**	**0.5**	**0.025**	**1.9**	**1.9**	**bd**	**0.003**	**0.009**	**0.008**	**0.016**	**0.005**	**bd**	**bd**	**7**	**5**	**1**	**ND**	**bd**
	12/14/2006	08:25 to 09:26	0.3	0.010	2.5	2.3	0.2	0.001	0.012	0.015	0.026	bd	bd	bd	64	18	2	ND	bd
	5/25/2007	**15:07 to 16:08**	**0.2**	**0.047**	**1.9**	**1.9**	**bd**	**0.004**	**0.001**	**0.002**	**0.002**	**bd**	**bd**	**bd**	**ND**	**4**	**3**	**3**	**bd**
	5/31/2007	08:24 to 09:10	0.3	0.033	2.1	2.0	bd	0.009	0.003	0.004	0.006	0.009	bd	bd	ND	45	17	13	bd
	8/28/2007	**14:45 to 15:44**	**0.2**	**0.035**	**1.9**	**1.8**	**bd**	**0.017**	**0.003**	**0.005**	**0.007**	**bd**	**bd**	**bd**	**ND**	**6**	**4**	**2.8**	**bd**
	8/29/2007	12:44 to 13:45	0.3	0.019	1.9	1.9	bd	ND	0.015	0.012	0.026	bd	bd	bd	ND	13	5	2.7	bd
	10/12/2007	**14:47 to 15:48**	**0.2**	**0.038**	**1.9**	**1.9**	**bd**	**0.001**	**bd**	**0.001**	**0.001**	**bd**	**bd**	**bd**	**ND**	**16**	**6**	**4.4**	**bd**

Notes:

bd = below detection limit **ND** - no data **ppm** = parts per million **ng/m³** = nanograms per cubic meter **µg/m³** = micrograms per cubic meter

Table A3: Operator remarks and weather conditions

Location	Date	Sample Times	Comments	Temp °C	RH %RH	WSP KPH	WDR DEG
Carvel	11/18/2004	09:18 to 10:18	Almost calm	-2.0	70.0	3.1	145
	6/22/2005	16:52 to 17:52		19.1	62.8	5.2	104
	2/17/2006	10:05 to 11:05		-15.2	50.4	9.8	251
	5/5/2006	09:11 to 10:15		20.7	25.4	8.1	273
	5/8/2006	15:34 to 16:36		5.6	84.4	14.7	266
	12/13/2006	10:28 to 11:27		-3.2	78.2	6.7	120
	12/14/2006	15:19 to 16:19	No odours	-1.3	61.1	1.9	202
Alberta Beach	5/31/2007	16:12 to 17:01	Beach corner more open location	30.2	27.8	8.5	224
	8/28/2007	07:55 to 08:59	Sunny, light winds	10.5	81.8	5.6	275
	11/16/2004	15:09 to 16:09		8.2	47.8	3.5	124
	11/18/2004	10:40 to 11:40		0.4	65.2	4.1	259
	6/22/2005	15:31 to 16:31		21.2	51.8	9.3	188
	10/5/2005	09:16 to 10:16		5.3	69.0	13.9	146
	2/17/2006	16:49 to 17:49	Possible vehicle exhaust interferenc	-7.0	43.8	8.6	288
	3/8/2006	09:59 to 10:57	No odours	1.2	56.3	8.9	159
	5/5/2006	16:03 to 17:04		24.2	16.5	7.3	238
	5/8/2006	14:08 to 15:08	Light rain	5.3	68.7	20.6	257
	12/13/2006	17:18 to 18:19		-6.9	85.5	1.9	149
	12/14/2006	13:55 to 14:57	No odours	2.4	49.5	4.7	133
	5/25/2007	08:40 to 09:42	Sunny	14.9	51.6	13.4	107
	5/31/2007	13:55 to 14:55	Clear sky	28.0	33.4	6.9	297
	8/28/2007	09:21 to 10:21	Sunny, light winds	13.6	64.1	6.7	317
	8/29/2007	08:11 to 09:17		14.8	64.9	5.4	187
	10/12/2007	08:21 to 09:22	Sunny, light winds	4.5	75.0	1.9	130
Darwell	11/16/2004	13:49 to 14:49		9.1	45.7	7.8	204
	10/5/2005	10:32 to 11:33		8.7	58.5	9.5	150
	3/8/2006	11:14 to 12:15	No odours	7.4	33.3	6.6	175
	5/25/2007	09:59 to 11:00	Sunny	18.3	40.9	10.9	141
	8/29/2007	09:39 to 10:42		19.3	50.4	3.7	171
	10/12/2007	09:38 to 10:38	Sunny, light winds	9.4	60.0	2.7	232
Seba Beach	11/16/2004	12:27 to 13:27		7.6	55.6	4.9	185
	11/18/2004	12:13 to 13:13	Light winds near dock	0.5	61.5	2.8	235
	6/22/2005	14:00 to 15:00		23.1	41.0	8.1	248
	10/5/2005	11:50 to 12:51	Reposition @ 12:06 due to exhaust interference	11.7	48.0	6.4	148
	2/17/2006	15:12 to 16:12		-3.9	26.7	5.7	276
	3/8/2006	12:32 to 13:33	No odours	4.1	55.8	3.7	87
	5/5/2006	14:27 to 15:26		23.7	19.8	4.3	157
	5/8/2006	12:36 to 13:36		8.6	63.9	8.5	239
	12/13/2006	15:37 to 16:37	Very light wind Exaust interference	-6.7	90.4	1.4	236
	12/14/2006	12:19 to 13:22	No odours	-4.4	71.0	1.9	147
	5/25/2007	11:18 to 12:20	Sunny	21.5	31.4	6.5	144
	5/31/2007	12:22 to 13:22	Clear sky	26.8	33.8	8.6	119
	8/28/2007	10:54 to 11:55	Sunny, light winds	19.0	41.1	5.9	260
	8/29/2007	11:02 to 12:10		20.7	48.7	3.6	110
	10/12/2007	10:54 to 11:56	Sunny, light winds	11.7	41.1	5.5	107

Continued on the next page

Notes:

Temp = Temperature in degrees centigrade **RH** = Relative humidity in percentage **WSP KPH** = Wind speed in Km/hr
WDR DEG = Wind direction in degrees

Table A3 continued from previous page: Operator remarks and weather conditions

Location	Date	Sample Times	Comments	Temp °C	RH %RH	WSP KPH	WDR DEG
Wabamun	11/16/2004	11:07 to 12:07		8.0	52.8	4.3	217
	11/18/2004	13:32 to 14:32		1.6	60.9	5.5	254
	6/22/2005	12:38 to 13:38		20.9	48.4	13.9	298
	10/5/2005	13:12 to 14:12		11.7	50.7	12.2	146
	2/17/2006	13:53 to 14:53		-4.0	24.3	9.7	277
	3/8/2006	13:57 to 14:55	No odours	9.2	32.6	8.1	123
	5/5/2006	13:07 to 14:08		24.5	18.8	6.4	209
	5/8/2006	11:15 to 12:18		7.1	71.4	18.1	295
	12/13/2006	14:16 to 15:18	Plume from Wabamun plant dispersing high over MAML, low winds	0.1	83.5	2.5	190
	12/14/2006	10:59 to 12:01	No odours	3.3	54.3	1.5	149
	5/25/2007	12:38 to 13:37	Sunny	21.0	33.6	10.0	166
	5/31/2007	11:04 to 12:04	Clear sky	27.4	32.2	6.4	179
	8/28/2007	12:13 to 13:12	Sunny, light winds	18.0	40.9	9.9	231
	8/29/2007	15:31 to 16:31	Very light variable winds	23.3	35.1	4.2	166
	10/12/2007	12:13 to 13:14	Sunny, light winds	17.4	31.6	2.7	171
Ironhead Golf Course	11/16/2004	09:46 to 10:46		6.5	64.2	3.0	86
	11/18/2004	14:44 to 15:44		0.6	67.8	6.7	286
	6/22/2005	11:28 to 12:28		22.0	50.4	6.0	232
	10/5/2005	14:29 to 15:30		10.0	56.7	14.2	150
	2/17/2006	12:41 to 13:41		-7.5	40.0	7.4	279
	3/8/2006	15:07 to 16:05	No odours	10.1	28.5	7.4	127
	5/5/2006	11:50 to 12:54		25.0	15.5	7.8	288
	5/8/2006	10:01 to 11:01	Windy	7.2	80.4	19.2	292
	12/13/2006	13:05 to 14:05		1.9	55.3	3.5	93
	12/14/2006	09:47 to 10:47	No odours	-1.5	75.8	1.7	246
	5/25/2007	13:48 to 14:49	Sunny	20.5	32.0	13.2	177
	5/31/2007	09:48 to 10:47	Clear sky	26.0	40.9	4.1	239
	8/28/2007	13:22 to 14:23	Sunny, light winds	20.1	38.4	5.6	253
	8/29/2007	14:06 to 15:16		24.3	30.8	3.7	279
	10/12/2007	13:27 to 14:28	Sunny, light winds	16.8	29.1	4.0	116
Keephills	11/16/2004	08:22 to 09:22	very calm conditions	-1.6	90.4	1.6	137
	11/18/2004	16:10 to 17:10	calm, elvated dust readings from vehicular traffic. Looks hazy	-1.0	81.3	1.7	183
	6/22/2005	10:04 to 11:04		19.6	63.1	15.1	293
	10/5/2005	15:48 to 16:49		11.9	53.2	4.2	160
	2/17/2006	11:23 to 12:23		-9.9	34.1	10.3	264
	3/8/2006	16:25 to 17:25	No odours	5.0	47.1	7.1	120
	5/5/2006	10:31 to 11:33	Pick up SO2	25.1	16.5	6.7	240
	5/8/2006	08:44 to 09:43	Light rain	5.2	87.8	15.8	237
	12/13/2006	11:45 to 12:45		-1.2	69.6	3.1	104
	12/14/2006	08:25 to 09:26	No odours	-11.1	95.6	1.6	203
	5/25/2007	15:07 to 16:08	Sunny	21.2	30.9	18.1	154
	5/31/2007	08:24 to 09:10	Cut hour short, exhaust interfernce	24.4	38.4	4.7	177
	8/28/2007	14:45 to 15:44	Sunny, light winds	18.9	35.9	7.7	290
	8/29/2007	12:44 to 13:45		23.1	35.6	4.7	214
	10/12/2007	14:47 to 15:48	Sunny, light winds	12.5	34.9	7.9	114

Notes:

Temp = Temperature in degrees centigrade **RH** = Relative humidity in percentage **WSP KPH** = Wind speed in Km/hr
WDR DEG = Wind direction in degrees

Table A4: Median and maximum one-hour average concentrations for a Wabamun area air quality survey conducted in 2000/01[4].

Site	Location	Number of 1-hr samples	CO PPM	O_3 PPM	THC PPM	CH_4 PPM	RHC PPM	SO_2 PPM	NO PPM	NO_2 PPM	NO_x PPM	NH_3 PPM	TRS PPM	H_2S PPM	TSP $\mu g/m^3$	PM_{10} $\mu g/m^3$	$PM_{2.5}$ $\mu g/m^3$	PAH ng/m^3
			Median 1-hour average															
1	**Carvel**	8	**0.14**	**0.025**	**2.0**	**2.0**	**0.1**	**0.001**	**0.002**	**0.004**	**0.006**	**0.004**	**bd**	**bd**	**33**	**22**	**4**	**bd**
2	Alberta Beach	8	0.19	0.029	2.0	2.0	0.1	0.001	bd	0.003	0.003	0.002	bd	bd	54	35	5	bd
3	**Darwell**	9	**0.20**	**0.028**	**2.0**	**1.9**	**0.1**	**0.002**	**0.003**	**0.004**	**0.007**	**0.001**	**0.001**	**bd**	**55**	**33**	**7**	**bd**
4	Seba Beach	8	0.23	0.027	2.0	1.9	0.1	0.002	0.004	0.006	0.009	0.004	0.001	bd	57	28	3	bd
5	**Wabamun**	8	**0.20**	**0.028**	**2.0**	**1.9**	**0.1**	**0.003**	**0.004**	**0.007**	**0.010**	**0.005**	**0.001**	**bd**	**38**	**24**	**4**	**bd**
6	Ironhead Golf Course	8	0.15	0.030	1.9	1.9	0.1	0.002	0.003	0.005	0.007	0.003	0.001	bd	81	40	6	bd
7	**Village of Keephills**	8	**0.10**	**0.025**	**2.0**	**2.0**	**bd**	**0.003**	**0.003**	**0.007**	**0.009**	**0.006**	**0.001**	**bd**	**32**	**22**	**4**	**bd**
8	Telfordville	8	0.10	0.024	2.1	2.0	0.1	bd	0.003	0.004	0.006	0.005	bd	bd	54	34	5	bd
			Maximum 1-hour average															
1	**Carvel**	8	**0.32**	**0.038**	**2.3**	**2.4**	**0.1**	**0.003**	**0.017**	**0.012**	**0.027**	**0.010**	**0.001**	**0.001**	**284**	**180**	**18**	**5**
2	Alberta Beach	8	0.44	0.048	2.2	2.3	0.1	0.002	0.012	0.009	0.019	0.020	0.002	0.001	125	74	9	11
3	**Darwell**	9	**0.19**	**0.032**	**2.0**	**1.9**	**0.1**	**0.003**	**0.004**	**0.005**	**0.008**	**0.005**	**0.001**	**bd**	**114**	**61**	**8**	**bd**
4	Seba Beach	8	0.42	0.056	2.2	2.1	0.2	0.017	0.012	0.015	0.024	0.020	0.002	0.001	421	225	23	3
5	**Wabamun**	8	**0.48**	**0.057**	**2.2**	**2.2**	**0.1**	**0.032**	**0.017**	**0.012**	**0.029**	**0.014**	**0.002**	**0.001**	**138**	**75**	**9**	**bd**
6	Ironhead Golf Course	8	0.52	0.054	2.2	2.2	0.2	0.008	0.009	0.008	0.012	0.013	0.002	0.001	273	148	14	bd
7	**Village of Keephills**	8	**0.35**	**0.042**	**2.5**	**2.4**	**0.1**	**0.010**	**0.016**	**0.015**	**0.030**	**0.014**	**0.002**	**0.001**	**137**	**82**	**10**	**11**
8	Telfordville	8	0.19	0.050	3.5	3.3	0.5	0.002	0.012	0.015	0.017	0.013	0.001	0.001	807	534	42	7
	AAAQO		13.0	0.082	n/a	n/a	n/a	0.172	n/a	0.212	n/a	2.000	n/a	0.010	n/a	n/a	n/a	n/a

Notes:

bd – below detection limit **ND** - no data **ppm** - parts per million **ng/m^3** = nanograms per cubic meter **$\mu g/m^3$** = micrograms per cubic meter

[4] Summary of the data for the current study (2004-2007) is presented in Table 2 in the ***Result and Discussion*** section.

Appendix B

The median concentration

The median concentration is a common way of representing the central value for environmental data. Most environmental data usually consist of a distribution that is skewed to the right; that is most data values are low and only a few are high. For such data sets, the arithmetic mean will be biased by the high concentrations; the resulting value may not be representative of the central value for the data set. For example, a data distribution consisting of five numbers: 1, 2, 2, 3 and 10. The arithmetic mean of these data is 3.6 and the median is 2. In this case, the arithmetic mean is biased high by the extreme value of 10. The median is the middlemost value in the data set; thus more representative of the central value of the data distribution. Fifty percent of the values in the dataset are below the median and fifty percent are above.

Alberta's Ambient Air Quality Objectives

Alberta's Ambient Air Quality Objectives[1] are established under Section 14 of the Environmental Protection and Enhancement Act (EPEA R.S.A. 2000, c.E-12, as amended). EPEA provides for the development of environmental objectives for Alberta.
The Ambient Air Quality Objectives are used for:

- Reporting on the state of the atmospheric environment in Alberta.
- Reporting to Albertans on the quality of the air through Alberta's Air Quality Index (AQI).
- Establishing approval conditions for regulated industrial facilities.
- Evaluating proposals to construct facilities that will have air emissions.
- Guiding special ambient air quality surveys.
- Assessing compliance near major industrial air emission sources.

Some of Alberta's Ambient Air Quality Objectives are based on odour perception. This is the case for ammonia, nitrogen dioxide and hydrogen sulphide. For these chemicals, people are likely to detect an odour at concentrations well below levels that may affect human health. Alberta's Ambient Air Quality Objectives for one-hour average concentration of pollutants monitored by the MAML are listed in Table B1. Alberta also has a one-hour average ambient concentration guideline for $PM_{2.5}$ of 80 $\mu g/m^3$ this is based on the Canada Wide Standard for $PM_{2.5}$.

Table B1: Alberta's Ambient Air Quality Objective measured by the MAML

Pollutant	One-hour AAAQO (ppm)	Basis for Objective
Ammonia	2	odour perception
Carbon monoxide	13	oxygen carrying capacity of blood
Nitrogen dioxide	0.212	odour perception
Ozone	0.082	reduction of lung function and effects on vegetation
Hydrogen sulphide	0.01	odour perception
Sulphur dioxide	0.172	pulmonary function

ppm - parts per billion

[1] *Alberta Ambient Air Quality Objectives.* Alberta Environment. April 2005.

The Mobile Air Monitoring Laboratory (MAML)

The MAML is a 27-foot (8.2 m) vehicle that has been specially designed and equipped to measure air quality. It houses a variety of instruments that continuously sample the air at specified time or distance intervals. The MAML is equipped with:

- a dual computer system custom-programmed to accept and record the measurement of air samples from each analyser,
- a GPS (Global Positioning System) that identifies the MAML's location as it moves around Alberta,
- an exhaust purifying system that minimizes emissions from the vehicle and
- two on-board generators that are also equipped with exhaust scrubbers

Table B2 lists the pollutants and meteorological data monitored by the MAML. Also indicated are the lower and upper detection limits for each monitored species.

Figure B1: Alberta Environment's Mobile Air Monitoring Laboratory

Table B2: Pollutants and meteorological data monitoring by the MAML.

Pollutant	Operating Range	
	Lower Detection Limit*	**Upper Detection Limit****
Ammonia (NH_3)	0.001 ppm	5 ppm
Ozone (O_3)	0.001 ppm	0.5 ppm
Carbon Monoxide (CO)	0.1 ppm	50 ppm
Hydrocarbons		
Methane (CH_4)	0.1 ppm	20 ppm
Reactive Hydrocarbons (RHC)	0.1 ppm	20 ppm
Total Hydrocarbons (THC)	0.1 ppm	20 ppm
Oxides of nitrogen		
Nitrogen dioxide (NO_2)	0.0006 ppm	1 ppm
Nitric Oxide (NO)	0.0006 ppm	1 ppm
Oxides of nitrogen (NO_x)	0.0006 ppm	1 ppm
Particulate Matter		
Total Suspended Particulates (TSP)	1 $\mu g/m^3$	1.0 g/m^3
Particulate Matter <10µm (PM_{10})	1 $\mu g/m^3$	1.0 g/m^3
Particulate Matter <2.5µm ($PM_{2.5}$)	1 $\mu g/m^3$	1.0 g/m^3
Particulate Matter <1µm ($PM_{2.5}$)	1 $\mu g/m^3$	1.0 g/m^3
Polycyclic Aromatic Hydrocarbons (PAH)	3 ng/m^3	1000 ng/m^3
Sulphur Compounds		
Hydrogen Sulphide (H_2S)	0.001 ppm	1 ppm
Total Reduced Sulphur (TRS)	0.001 ppm	1 ppm
Sulphur Dioxide (SO_2)	0.001 ppm	2 ppm
Meteorological data		
Wind Speed	0 km/hr	200 km/hr
Wind Direction	0 degrees	360 degrees
Temperature	-40 °C	50 °C
Relative humidity	0%	100%

ppm - parts per million

ng/m^3 = nanograms per cubic meter

$\mu g/m^3$ = micrograms per cubic meter

g/m^3 = grams per cubic meter

* The ***lower detection limit*** indicates the *minimum* amount of pollutant and the lower limit of meteorological data can be measured by the instrument.

** The ***upper detection limit*** indicates the *maximum* amount of pollutant the instrument can detect and the upper limit for meteorological data measured. This limit is set to provide the optimum precision over that range. The upper limit can be raised, however, precision at the lower levels (where most levels are monitored) is then compromised.